DOI:
10.1080/13504851.2017.1327118

Document Version
Peer reviewed version

Comparing private and government schools in India: The devil is in the maths

Sunil Mitra Kumar*

Abstract

Recent research shows that the gap in learning achievement between private and government schools in India can be explained away by self-selection. Analysing four rounds of panel data and distinguishing between 'knowing' and 'applying' dimensions of maths learning, I find that there is no private school advantage in the applying domain but that there is an advantage in the knowing domain.

Keywords: Private schools, India, Mathematical competencies, Propensity score matching

JEL: I21, I25

*India Institute, King's College London, Strand, London WC2R 2LS, UK, sunil.kumar@kcl.ac.uk. I am grateful to Mili, Christopher Winch, Shaun Hargreaves-Heap, and Ragupathy Venkatachalam for insightful discussions and comments.

1 Introduction

This paper addresses an important debate over whether private schools perform better than government schools in India. This debate has far-reaching implications for developing countries more generally. Despite increased access to education, few countries have school systems that provide quality education for all, and there is mixed evidence as to whether private schools can address this gap.[1]

Enrolments in Indian private schools are growing (Kingdon 2007), and parents opt for private schools if they can afford them (Srivastava and Noronha 2016). While this suggests that private schools increase pupils' learning and there is some evidence to support this view (e.g. Kingdon 1996; Goyal 2009), recent studies including Chudgar and Quin (2012), Singh (2015) and Muralidharan and Sundararaman (2015) find that the private school advantage can largely be explained away by self-selection. The aim of this paper is to test whether private schools do offer an advantage having controlled for any effects of self selection.

Towards this end, I distinguish between two dimensions of maths learning: 'Knowing' and 'applying'. 'Knowing' involves number identification and arithmetic operations and 'applying' entails being able to apply mathematical concepts and reasoning in real life. I compare learning in both domains in private and government schools using four rounds of panel data from the Young Lives study (Huttly and Jones 2014; Boyden 2014b,a; Boyden et al. 2016). I find that applying-maths scores are lower than knowing-maths scores in both types of schools, and that there is no private school advantage in the applying domain. But, there is a private school advantage in knowing-maths scores of at least 0.26σ which is strongest (0.65σ) for children who have throughout studied in private school.

As far as I know, this is the first attempt to distinguish between these twin types

[1]For instance, Jimenez and Lockheed (1995) provide cross-country evidence favouring private schools, whereas Newhouse and Beegle (2006) and Somers et al. (2004) do not find evidence of a private-school advantage.

of maths abilities in the Indian context. The distinction and the results are important because they explain why parents might prefer private schools even though there is no evidence that they offer an advantage in the 'applying' domain. From a policy perspective, they are also important because they suggest that increasing enrolment in private schools is unlikely to improve real-world mathematical abilities.

2 Data

The Young Lives study tracks 2000 children in the states of Andhra Pradesh and Telangana over four survey rounds, conducted in 2002 (when the children were aged 1), 2006 (aged 5), 2009 (aged 8), and 2013 (aged 12). To effectively control for self-selection into school types, I control for children's schooling trajectories from age 5 onwards besides a detailed set of household characteristics: the child's sex, caste, a dummy for first-born, father and mother's years of education, the household's primary occupation, household size through survey rounds 1-4, and household income through rounds 2-4. Income data are not available in round 1, so instead I use four indices as proxies: quality of housing, furniture, amenities (cooking fuel, toilet etc.) and electrical appliances, each calculated using polychoric principal components analysis (Kolenikov and Angeles 2009). I also control for region (Coastal Andhra Pradesh, Rayalaseema, Telangana) and type of habitation (rural or urban). 1630 observations remain after dropping cases where on one or more variables are missing.

2.1 Mathematical abilities

School education aims to impart mathematical abilities, and in particular, the ability to apply mathematical concepts to solve real-world problems (Kilpatrick et al. 2001). To do so, a child must *know* concepts like numbers or operations like addition, and recognise how and when to *apply* them according to the problem. Knowing and Applying are thus two key cognitive domains for assessing mathematical competencies in the Trends

in International Mathematics and Science Study, an international benchmark assessment (see Mullis et al. 2009). Questions that test application are usually formulated as word-problems, and involve translating information from language to maths, and selecting an appropriate operation. Instead, problems that test knowing involve the ability to recall information, recognise symbols (like ÷), and implement the corresponding algorithms.

Example Q1. A piece of rope 204 cm. long is cut into 4 equal pieces. Which of these gives the length of each piece in centimeters?

a) 204 + 4
b) 204 x 4
c) 204 – 4
d) 204 ÷ 4

Example Q2. Based on the receipt, answer the following question[s] by marking the correct answer with an X.

Anitha wants to buy 38 T-shirts. How much will she pay?

a) Rs. 325
b) Rs. 494
c) Rs. 484
d) Rs. 304

Chennai Silks Shop

RECEIPT N° 0568
Date: [October 4th, 2012]

No. of items	DESCRIPTION	UNIT PRICE	LINE TOTAL	DISCOUNT
10	Trousers	[Rs.12]	[Rs.120]	[Rs. 24]
25	T-shirts	[Rs.13]	[Rs.325]	No discount
78	Socks	[Rs. 4]	[Rs.312]	[Rs. 35]
37	Dresses	[Rs.20]	[Rs.740]	No discount
49	Skirts	[Rs. 8]	[Rs.392]	[Rs. 33]
			SUBTOTAL	[Rs. 92] TOTAL DISCOUNT
			TOTAL	

Figure 1: Two applying-maths problems (Source: Boyden et al. 2016)

The round 4 Young Lives maths test questionnaire contains 29 questions in two separate sections: 10 word problems that test the ability to apply mathematical concepts, and 19 problems that test mathematical knowledge in terms number recognition and arithmetic operations. Two questions of each type are presented in figures 1 (applying) and 2 (knowing). I create two scores corresponding to both sets of questions. Raw scores are calculated by adding one mark for each question answered correctly and zero otherwise. Both scores are scaled to the range 0-1, and I further normalise them while estimating school-type treatment effects to aid simple interpretation.

Table 1: Household characteristics by school type

(N=1630)	Private school at age 12		Government school at age 12	
Characteristic	Mean	(S.D.)	Mean	(S.D.)
Sector				
Urban	0.474	-	0.091	-
Rural	0.526	-	0.909	-
Region				
Coastal Andhra	0.311	-	0.378	-
Rayalaseema	0.276	-	0.321	-
Telangana	0.413	-	0.301	-
Child and household characteristics				
Child is first-born	0.420	-	0.450	-
Male	0.618	-	0.486	-
Female	0.382	-	0.514	-
Father years of education	7.563	(5.092)	2.805	(4.133)
Mother years of education	5.509	(4.897)	1.550	(3.038)
Household size in round 1	5.464	(2.400)	5.467	(2.376)
Household size in round 2	5.537	(2.308)	5.576	(2.202)
Household size in round 3	5.426	(2.295)	5.542	(2.242)
Household size in round 4	4.966	(1.947)	4.925	(1.677)
Household Income in round 2 (Rs '000)	68.770	(109.213)	25.479	(28.369)
Household Income in round 3 (Rs '000)	173.380	(376.506)	54.199	(96.670)
Household Income in round 4 (Rs '000)	180.907	(259.575)	83.373	(132.293)
Income proxies for round 1				
Housing index	0.529	(1.022)	-0.351	(1.208)
Furniture index	0.381	(0.845)	-0.238	(0.649)
Amenities index	0.613	(1.248)	-0.453	(0.739)
Electrical assets index	0.467	(0.917)	-0.331	(0.628)
Household occupation				
Farmer	0.183	-	0.253	-
Transport/trade/industry	0.300	-	0.121	-
Non-agricultural wage labour	0.260	-	0.497	-
Other	0.257	-	0.129	-
Household caste				
Scheduled Caste	0.102	-	0.246	-
Scheduled Tribe	0.073	-	0.203	-
Backward Caste	0.477	-	0.457	-
Other Castes	0.235	-	0.064	-
Non-Hindu	0.113	-	0.029	-

Notes:
This table presents means and proportions of household and child characteristics according to the school in which the child is enrolled, viz. private or government.
Housing, furniture, amenities and electrical assets indices are estimated using polychoric principal components analysis (Kolenikov and Angeles 2009)

Example Q1. Which of these is equal to 342?

a) 3000+400+2
b) 30+40+2
c) 300+40+2
d) d) 3+4+2

Example Q2. Solve 923 X 123:

a) 113283
b) 5526

Figure 2: Two knowing-maths problems (Source: Boyden et al. 2016)

Table 2: Maths scores by school type and schooling trajectory

		Type of maths			
		Applying		Knowing	
School type	Proportion	Mean	S.D.	Mean	S.D.
Overall Comparison					
Private school at age 12	0.396	0.327	0.226	0.609	0.252
Government school at age 12	0.604	0.220	0.194	0.463	0.268
Specific schooling trajectories					
Private school at ages 5, 8, 12	0.155	0.353	0.229	0.648	0.227
Government school at ages 5, 8, 12	0.167	0.197	0.192	0.440	0.275
Private school at ages 8 & 12 and not in school at age 5	0.113	0.308	0.215	0.596	0.268
Government school at ages 8 & 12 and not in school at age 5	0.317	0.222	0.192	0.464	0.263
Other trajectories	0.248	0.281	0.218	0.536	0.268

Notes:
This table presents average maths scores on procedural and reasoning-based abilities according to school type and selected schooling trajectory. The scores are scaled to the interval [0-1].
'Overall Comparison' scores refer to those of students enrolled in respective school types at age 12. These do not distinguish between (and are thus averaged over) the school type at ages 5 and 8.
All pair-wise comparisons using t-tests for procedural and reasoning abilities are highly significant (p=0.000) demonstrating a private school advantage in simple averages. For example, comparing students in private school at age 12 with their government school counterparts, or those in private school through ages 5, 8, 12 with their government school counterparts, and so on.

3 Methods and results

I use propensity score matching (Rosenbaum and Rubin 1983) to estimate the causal impact of school type on maths scores, controlling for schooling trajectories and household characteristics. Propensity scores are estimated using logit models (results in appendix A), and I use 1-1 matching, following Abadie and Imbens (2016) to adjust the standard

errors for the fact that the propensity score is itself also estimated.

Table 1 provides summary statistics according to children's school type at age 12. Table 2 summarises average maths scores in Applying and Knowing problems at age 12 by school type, and across the four most common schooling trajectories. Private school students have higher scores on average (p=0.000 in all cases), and Applying scores are lower than Knowing scores all round.

Table 3 provides three treatment effect estimates of private school enrolment on maths scores at age 12, including an overall effect and two finer-grained effects based on specific schooling trajectories shown in table 2. Row 1 of table 3 shows that students enrolled in private school at age 12 have no statistically significant advantage in Applying scores over their government school counterparts having controlled for schooling trajectories and background characteristics, but that Knowing scores are higher by 0.26σ (p=0.003). Row 2 shows that this pattern is intensified if we compare children enrolled in private school through ages 5, 8, and 12 with their government counterparts: the difference in Applying scores remains insignificant while the private school advantage in Knowing scores increases to 0.64σ (p=0.000). Row 3 shows that there is no private school advantage in either type of maths scores for the sample of children who remained enrolled in the same school type through ages 8-12 but were out of school at age 5.

4 Discussion

These results suggest that private schooling does not improve the ability to solve problems where the mathematical operations required have not been specified. These are precisely the sorts of problems encountered in real life, for which mathematical abilities are crucial. But private schooling does improve children's ability to solve arithmetic problems where the required mathematical operations have been made explicit. These are the types of problems likely encountered in exams, which could be one reason why parents discern a private school learning advantage. This also suggests a potential explanation

Table 3: Average treatment effects of private schooling

	Type of maths						
	Applying			Knowing			
Treatment	θ	S.E.	p-value	θ	S.E.	p-value	N
Private school at age 12 controlling for school type at ages 5 and 8[a]	0.131	0.135	0.333	0.256	0.085	0.003	1630
Private school at ages 5, 8 & 12[b]	0.236	0.535	0.659	0.643	0.033	0.000	522
Private school at ages 8 & 12 and out of school at age 5[c]	0.499	0.397	0.209	0.271	0.210	0.197	701

Notes:
This table presents average treatment effect estimates computed using propensity score matching for the indicated subsamples. Standard errors use the adjustment proposed by Abadie and Imbens (2016) to account for the fact that the propensity score is estimated. Both outcome variables are standardised, with mean zero and standard deviation 1.
[a] The comparison group is children enrolled in government school at age 12.
[b] The comparison group is children enrolled in government school at ages 5, 8 and 12.
[c] All children in this subsample were out of school at age 5. The comparison group is children enrolled in government school at ages 8 and 12.

for the mixed evidence in the literature, because depending on the relative weighting of both types of questions, an overall maths score may or may not reveal a private school advantage.

One wider implication of these findings is that increasing private school enrolments are unlikely to lead to better real-world mathematical abilities. Although I have not sought to in this paper, an open question remains as to how this ability shapes labour market outcomes, and data from the fifth round of the Young Lives survey conducted at age 16 (yet to be released) could help answer this question. The second implication is methodological. These results demonstrate why comparisons between private and government schools should also account for the relevance of different kinds of learning in the real world, and the sorts of skills such learning represents.

References

Abadie, A. and G. W. Imbens (2016). Matching on the estimated propensity score. *Econometrica 84*(2), 781–807.

Boyden, J. (2014a). *Young Lives: an International Study of Childhood Poverty: Round 2, 2006*. UK Data Service. SN: 6852.

Boyden, J. (2014b). *Young Lives: an International Study of Childhood Poverty: Round 3, 2009*. UK Data Service. SN: 6853.

Boyden, J., T. Woldehanna, S. Galab, A. Sanchez, M. Penny, and L. T. Duc (2016). *Young Lives: an International Study of Childhood Poverty: Round 4, 2013-2014*. UK Data Service. SN: 7931.

Chudgar, A. and E. Quin (2012). Relationship between private schooling and achievement: Results from rural and urban India. *Economics of Education Review 31*(2012), 376–390.

Goyal, S. (2009). Inside the house of learning: the relative performance of public and private schools in Orissa. *Education Economics 17*(3), 315–327.

Huttly, S. and N. Jones (2014). *Young Lives: an International Study of Childhood Poverty: Round 1, 2002*. UK Data Service. SN: 5307.

Jablonka, E. (2003). Mathematical Literacy. In A. J. Bishop, M. A. Clements, C. Keitel, J. Kilpatrick, and F. K. S. Leung (Eds.), *Second International Handbook of Mathematics Education*, Number 10 in Springer International Handbooks of Education, pp. 75–102. Springer Netherlands.

Jimenez, E. and M. E. Lockheed (1995). *Public and private secondary education in developing countries: A comparative study*. Washington D.C.: World Bank Discussion Papers No. 309, The World Bank.

Kilpatrick, J., J. Swafford, and B. Findell (Eds.) (2001). *Adding It Up: Helping Children Learn Mathematics*. Washington, D.C.: National Academy Press.

Kingdon, G. (2007). The progress of school education in India. *Oxford Review of Economic Policy 23*(2), 168–195.

Kingdon, G. (1996). The quality and efficiency of private and public education: A case study of urban India. *Oxford Bulletin of Economics and Statistics 58*(1), 57–82.

Kolenikov, S. and G. Angeles (2009). Socioeconomic status measurement with discrete proxy variables: Is principal component analysis a reliable answer? *Review of Income and Wealth 55*(1), 128–165.

Mullis, I.V.S., M. O. Martin, G. J. Ruddock, C. Y. O'Sullivan, and C. Preuschoff. (2009). *TIMSS 2011Assessment Frameworks*. TIMSS & PIRLS International Study Center Lynch School of Education, Boston College.

Muralidharan, K. and V. Sundararaman (2015). The Aggregate Effect of School Choice: Evidence from a Two-Stage Experiment in India. *The Quarterly Journal of Economics 130*(3), 1011–1066.

Newhouse, D. and K. Beegle (2006). The effect of school type on academic achievement evidence from Indonesia. *Journal of Human Resources 41*(3), 529–557.

Pearl, J. (2009). *Causality* (Second ed.). New York: Cambridge University Press.

Rosenbaum, P. R. and D. B. Rubin (1983). The Central Role of the Propensity Score in Observational Studies for Causal Effects. *Biometrika 70*(1), 41–55.

Singh, A. (2015). Private school effects in urban and rural India: Panel estimates at primary and secondary school ages. *Journal of Development Economics 113*, 16–32.

Somers, M., P. McEwan, and J. Willms (2004). How Effective Are Private Schools in Latin America? *Comparative Education Review 48*(1), 48–69.

Srivastava, P. and C. Noronha (2016). The myth of free and barrier-free access: Indias Right to Education Act–private schooling costs and household experiences. *Oxford Review of Education 42*(5), 561–578.

Appendix A Propensity score estimations

Table 4: Propensity score estimations

Covariate	Model 1		Model 2		Model 3	
School type at age 8						
government	(base)		-		-	
private	2.505***	(0.184)	-		-	
out of school	1.499	(1.127)	-		-	
School type at age 5						
government	(base)		-		-	
private	0.495	(0.270)	-		-	
out of school	0.0868	(0.219)				
Type of locality						
Urban	(base)		(base)		(base)	
Rural	-0.368	(0.293)	-1.309*	(0.620)	-0.618	(0.554)
Region						
Coastal Andhra	(base)		(base)		(base)	
Rayalaseema	0.609**	(0.224)	0.120	(0.520)	0.749	(0.410)
Telangana	0.619**	(0.223)	1.757**	(0.535)	1.610***	(0.435)
Household caste-group						
SC	(base)		(base)		(base)	
ST	0.525	(0.303)	0.360	(0.736)	0.700	(0.549)
BC	0.680**	(0.226)	0.905	(0.517)	1.204**	(0.409)
Other, Hindu	1.209***	(0.299)	1.840**	(0.667)	2.330***	(0.530)
non-Hindu	0.849*	(0.378)	1.978*	(0.946)	1.637*	(0.730)
Household occupation						
independent farmer	(base)		(base)		(base)	
transport/trade/industry	-0.678*	(0.283)	-0.798	(0.675)	-0.0554	(0.491)
nonagri wage	-0.690**	(0.231)	-0.812	(0.556)	-0.632	(0.364)
other	-0.516	(0.281)	-1.024	(0.689)	-0.244	(0.474)
Other child and household characteristics						
First-born child	0.0592	(0.167)	-1.260**	(0.399)	-0.0911	(0.280)
Female	-0.534**	(0.163)	-1.675***	(0.408)	-1.095***	(0.283)
Father's education (yrs)	0.0661***	(0.0193)	0.127**	(0.0434)	0.108***	(0.0319)
Mother's education (yrs)	0.0389	(0.0247)	0.0938	(0.0578)	0.0883*	(0.0438)
Household size age 1	0.0308	(0.0416)	-0.195	(0.103)	0.113	(0.0691)
Household size age 5	-0.0235	(0.0572)	-0.214	(0.159)	-0.200*	(0.0977)
Household size age 8	-0.0685	(0.0554)	-0.123	(0.159)	-0.0267	(0.0935)
Household size age 12	0.0180	(0.0557)	0.00744	(0.126)	-0.274**	(0.105)
(log) HH income at age 5	0.227*	(0.102)	0.795**	(0.296)	0.271	(0.184)
(log) HH income at age 8	0.0760	(0.0914)	0.722**	(0.232)	0.337*	(0.162)
(log) HH income at age 12	0.268*	(0.111)	0.409	(0.241)	1.126***	(0.213)
House-quality index at age 1	0.287***	(0.0822)	0.251	(0.181)	0.123	(0.141)
Furniture assets index at age 1	0.0164	(0.122)	0.354	(0.278)	0.0892	(0.219)

Amenities index at age 1	0.117	(0.122)	0.201	(0.296)	0.400	(0.233)
Electrical assets index at age 1	0.0403	(0.136)	0.934**	(0.346)	0.489*	(0.221)
Constant	-8.358***	(1.552)	-17.55***	(3.568)	-19.27***	(3.100)
N	1630		525		701	

Notes:
Models 1-3 provide results for logit models used to estimate the propensity score.
Standard errors are in parentheses. * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.
Model 1: Children in private school at age 12 are coded as 1, and those in govt school as 0.
This model also controls for school type at ages 5 and 8
Model 2: Children in private school through ages 5-12 are coded as 1,
and those in govt school through ages 5-12 as 0.
Model 3: Children in private school through ages 8-12 and out of school at age 5 are coded as 1.
Those in govt school through ages 8-12 and out of school at age 5 are coded as 0.